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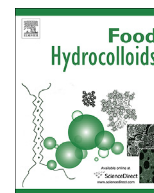

Pasteurization and chilled storage of restructured fish muscle products based on glucomannan gelation

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ABSTRACT

The effect of pasteurization and stability during subsequent chilled storage of three fish restructured prototypes made with 1.25% glucomannan and fish mince (sawdust from cutting of frozen fish blocks) was examined through physicochemical (water binding ability, mechanical and rheological behaviour), microbiological and sensory analyses. Three lots were made: control lot (C); lot O (with 5% added fish oil), and lot S (with 0.8% added NaCl). The three lots were pasteurized (80 °C 20 min) and stored at 5 °C. Analyses were carried out at 1, 7, 21 and 35 days of chilled storage.

Pasteurization produced a significant decrease in water binding capacity (WBC) and cooking loss (CL), less evident in lots O and S, due to changes in structure. In the case of lot O, an emulsion was formed in gel network, making this sample less acceptable from a sensory point of view. The addition of salt (lot S) produced an ionic situation more conducive to protein-polysaccharide associations, thus reinforcing the gel network.

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1. Introduction

The last few decades have seen an increase in the consumption of fish due to consumer perception of the health benefits of both lean and fatty fish (Rosnes, Skara, & Skipnes, 2011), and particularly to increasing demand for quality, variety and new seafood products based on restructuring (Kennedy, Storrs, Devoluy & Cruveiller, 2007). Various different technologies are used for seafood restructuring. Thermally-induced gelation is the most common method, but for this technology to work, the muscle proteins must retain their protein functionality so as to ensure good gelling capacity. However, there are many muscle by-products — one of the sources of raw material for making fish restructurates — which lack or have largely lost protein functionality as a result of prior thermal or mechanical processing, so that texturizing by thermally-induced gelation is impossible. A new possibility to get round this technological problem and make seafood products from muscles lacking functionality is to add konjac glucomannan (KGM) — a neutral hydrocolloid which is able to form thermostable hydrogels in the presence of an alkali — to the mince (Herranz, Borderias, Solas, & Tovar, 2012; Herranz, Borderias, Solo-de-Zaldívar, Solas, & Tovar, 2012; Herranz, Solo-de-Zaldívar, & Borderias, 2013). Thus, KGM would act as a gelling agent by forming a coupled network with protein particles in the continuous phase. In this way, gelation could be induced in a wide variety of fish muscle by products from food processing which have lost any functionality due to heating in order to make seafood analogues (Herranz et al., 2013). Moreover, konjac flour has high water-absorbing capacity (Chua, Baldwin, Hocking, & Chan, 2010) and has numerous physiological effects and therapeutic applications (González Canga et al., 2004; Zhang et al., 2001). Several papers have been published on the use of glucomannan (GM) in the making of restructured seafood products, with a view to choosing the best gelling conditions and testing them for thermostability. Experimentation with alkalinization conditions to improve gelation showed that 0.6 N KOH was the most suitable alkali to produce more elastic and time-stable GM gels (Herranz, Tovar, Solo-de-Zaldívar, & Borderias, 2012) and that the most suitable pH level was 11 (Solo-de-Zaldívar, Tovar, Borderías, & Herranz, 2014). As regards thermostability, a comprehensive thermo-rheological study of these GM gels conducted at different temperatures concluded that pre-heating reinforced the GM network (Herranz, Borderias, Solas, et al., 2012). Based on these studies, some fish prototypes were made using GM and non-functional fish muscle ("sawdust"). The flavour and texture closest to those of fish (hake) muscle were achieved with a prototype gel made from 75% sawdust and 25% aqueous

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glucomannan dispersion (AGD) with 1.25% GM (final concentration) (Herranz et al., 2013).

Pasteurization is one of the commonest methods for maintaining the safety and prolonging the shelf life of chilled fish products. It reduces the microbial load of fish products, but it is important to determine how heating affects the thermostability of a GM network with sawdust, since pasteurization may induce structural changes and a loss of textural quality. Especially in so sensitive a material as the gel, it can cause protein denaturation and a decrease in water binding capacity and colour, depending on the intensity of treatment (Fernández-Segovia, Camacho, Martínez-Navarrete, Escriche, & Chiralt, 2003).

Restructured products also offer the possibility of using different kinds of ingredients and additives to confer a particular taste, texture and/or functional capacity. Important among these ingredients are salt and fish oil owing to their organoleptic and functional characteristics.

The aim of this work was to study the effect of heating (pasteurization) on the physicochemical, rheological and sensory quality of prototype fish muscle restructurates made with sawdust and glucomannan with or without added salt and fish oil, and stored for 35 days at 5 °C.

2. Materials and methods

2.1. Raw material, additives and reagents

Konjac glucomannan (glucomannan purity 100%, MW: 11×10^5 Da) was purchased from Guinama, Valencia, Spain. Fish muscle "sawdust" obtained from sawing frozen blocks of hake (*Merluccius capensis*) as raw material was supplied by the company Frinova (Pescanova S.A., Vigo, Spain).

The fish oil used was from the company Omevital© (18/12 TG Gold, Cognis GmbH, Illertissen, Germany) and salt was NaCl from Panreac Química,S.A. (Barcelona, Spain). All the chemicals used were analytical grade and were supplied by Panreac Química S.A. (Barcelona, Spain).

2.2. Preparation of fish prototypes

Aqueous glucomannan dispersions (AGD) at 5% (w/v) were prepared as described in Herranz et al., (2013). Fish mince gel preparation was as follows: the fish ("sawdust") was homogenized for 5 min in a Stephan UM5 mixer (Stephan u. Söhne GmbH & , Germany) at 2 °C with vacuum. After that, 5% (w/v) AGD was added in proportion 25:75 (w/w) and homogenized for another 10 min, followed by addition of salt or oil. Then, 0.6 N KOH was added to bring the pH up to 11.0–11.1 and induce gelation. Cylindrical containers (diameter 3 cm × height 3.5 cm) and Petri dishes were filled with these three different homogenous mixtures and packed in vacuum conditions. After that, all samples were set first for 1 h at 30 °C and then for 4 h at 5 °C. These setting conditions were chosen based on prior tests to reduce the setting time as much as possible but maintaining texture similar to that of whole fish muscle (data not shown). The high pH values were reduced by immersing the samples in 0.2 M citrate-phosphate buffer at pH 5.1 (gel: buffer ratio was 1:10) for 16 h at 5 °C. In this way three lots with a 1.25% final glucomannan concentration were obtained: control lot (C); oil lot (O): control lot with addition of 5% fish oil, and salt lot (S): control lot with 0.8% NaCl, which is the regular amount in fish products. This amount of added oil (5%) was chosen based on previous experiments in which various restructured fish prototypes (in proportion 25:75 (w/w) with 1.25% final glucomannan concentration) were made with different oil levels (0%, 1%, 5% and 10%) at various pHs (data not shown). The objective of these prior assays was to mimic the texture and flavour of whole fish muscle with low (1%), medium (5%) and high fat content (10%), adding an oil enriched in long chain omega-3 fatty acids without off-flavour. Texture (puncture) and sensory analyses showed that the prototype with 5% oil most resembled a fish hake fillet in texture and flavour (data not shown).

Each lot was then divided into two parts: one part of these neutral gels was kept in chilled storage (5 °C). The other was vacuum packed in plastic bags and pasteurized in an oven (Rational Combi-Master CM6, Germany) at 80 °C for 20 min then immediately cooled in a water/ice slurry and stored at 5 °C. The non-pasteurized samples (0 day) were analysed after 24 h of chilled storage, and the pasteurized samples were kept at 5 °C for analysis after 1, 7, 21 and 35 days of chilled storage. The different samples were coded as shown in Table 1.

All the analytical data after 24 h of chilled storage (day 0), reported below, were taken from a previous study (Solo-de-Zaldívar, Herranz, Borderías, & Tovar, 2014).

2.3. Analyses

2.3.1. Proximate analyses and apparent viscosity of raw material

Moisture, fat and ash contents of raw fish were determined (AOAC, 2000) in quintuplicate. Crude protein content was measured in quadruplicate with a LECO FP-2000 Nitrogen Determinator (Leco Corporation, St Joseph, MI, USA). The apparent viscosity was measured with a Brookfield viscometer (Model DV-III, Brookfield Viscometers Ltd, Harlow, Essex, England) using a no. 1 disc spindle at a speed = 12 rpm following the method described by Borderias, Jimenez-Colmenero, and Tejada (1985).

2.3.2. Water binding capacity (WBC) and oil binding capacity (OBC)

Water binding capacity (WBC) was measured according to Eide, Borresen, and Strom (1982). Samples were cut into small pieces and then placed in centrifuge tubes and centrifuged (3000 *g*) at room temperature for 10 min in a Jouan MR1812 centrifuge (Saint Nazaire, France). WBC was expressed as percent water retained relative to the amount of water present in the sample prior to centrifuging. Samples formulated with 5% fish oil (Lot O) were tested for fat release according to Gómez-Guillén, Montero, Hurtado Hurtado & Borderías, (2000). The aqueous plus oil fraction which was retained in the filter after centrifugation was dried to constant weight. The result was expressed as oil binding capacity (OBC) per 100 g initial weight of product. All determinations were carried out in triplicate.

2.3.3. Cooking loss determination

Samples were weighed (40 g), cut into small pieces and placed in a plastic bag with small holes. This bag was then put into another bag with the holes at the bottom to drain the sample drip and was cooked hanging in an oven (Rational Combi-Master CM6) for 20 min at 100 °C. The sample was weighed after cooling. Cooking loss was expressed as g/100 g by weight difference between uncooked and cooked samples.

Table 1
Nomenclature of control samples (C), samples containing fish oil (O) and samples containing salt (S) during chilled storage.

Storage time (days)	Lot C	Lot O	Lot S
Fresh restructured	C 0	O 0	S 0
1	C 1	O 1	S 1
7	C 7	O 7	S 7
21	C 21	O 21	S 21
35	C 35	O 35	S 35

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